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Original Research Article

A radiological study of anatomical variations in ostiomeatal complex in patients with chronic rhinosinusitis

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ABSTRACT

Background: In ancient times the paranasal sinuses, without any anatomical differentiation, were thought to be a system of hollow spaces through which mucus produced by the brain was drained. Leonardo da Vinci in Milano in 1489 was the first to prepare and draw anatomical specimens of the paranasal sinuses; the drawings, however, only became accessible to scientific evaluation as late as 1901.
Methods: All adult patients (more than 20 years of age) attending the Outpatient department at ENT, diagnosed to have chronic rhinosinusitis, willing to undergoing Computed Tomographic evaluation were included in this study. Sample of 50 was selected using purposive sampling technique. All CT scans were obtained with GE Brightspeed scanner (16 slice MDCT scanner). Coronal sections were performed with the patients in prone position, with extended neck and the plane perpendicular to the infraorbitomeatal line.
Results: Agger nasi was the most common variation seen in 72% cases followed by dwviated nasal septum in 66% patients. Other variations found were lateral attachment of uncinate process in 54%, uncinate attachment to skull base in 33%, concha bullosa in 32%, overpneumatized bulla ethmoidalis in 21%, medial attachment of unicinate process to middle turbinate in 13%, paradoxical bent middle turbinate in 11%, haller cell seen in 6%. 56% had type I frontoethmoidal cells, 29% had type II, and 15% had type III frontoethmoidal air cells.
Conclusions: The presence of anatomical variants does not indicate a predisposition to sinus pathology but these variations may predispose patients to increased risk of intraoperative complications. The surgeon must pay close attention to anatomical variants in the preoperative evaluation avoid possible complications and improve success of management strategies.

Keywords: Chronic rhinosinusitis, Computed tomography, Anatomical variations

INTRODUCTION

Apart from the sensory function of smell, little has been known about the function and especially the anatomy of the paranasal system till the end of the last century. Until the late middle ages paranasal systems were attributed with obscure functions like holding the "grease" for the movement of the eyeballs, or allowing the brain to "drain its bad spirits" to the outer world. During the 17th and 18th century discussion was mainly about the function or purpose of the sinuses, and the rare anatomical studies were meant to support or prove one or the other "philosophies". Today's knowledge of the anatomy to a great deal goes back to the basic work of Emil Zuckerkandl of Austria, who starting from the 1870s described in subtile studies the anatomical and development details of the nose and the sinuses, opening an entire new field for scientific and surgical approach to the area.[1] Names like Grünwald, Onodi, Hajek and many others are closely linked with this creative period. Radiology, especially the development of conventional and computed tomography during the last two decades helped to "rediscover" the fascinating details and complex connections of the paranasal sinus system. Together with the development of the operating microscope and the endoscope this helped to open new ways for functional approaches and less radical microsurgery

In ancient times the paranasal sinuses, without any anatomical differentiation, were thought to be a system of hollow spaces through which mucus produced by the brain was drained. Leonardo da Vinci in Milano in 1489 was the first to prepare and draw anatomical specimens of the paranasal sinuses; the drawings, however, only became accessible to scientific evaluation as late as 1901. N. Highmore in England in 1651 presented the first detailed description and drawing of the maxillary sinus, and hence it is named Highmore's antrum. C. V. Schneider in Wittenberg, Germany, in 1660 realized that the mucus is not a product of the brain but is produced by the mucous lining of the region itself. F. G. J. Henle in Berlin in 1841 differentiated between various epithelia and described the special function of the ciliated epithelium of the respiratory tract.

The management and diagnostic modalities of sinonasal pathologies have undergone a drastic change in the past two decades. These dramatic changes initiated by the pioneering studies of Messerklinger, in which he demonstrated that each sinus has a predetermined mucociliary clearance pattern draining towards its natural ostium irrespective of additional openings that may have been created into the sinuses.[2] This philosophy of opening the natural ostium of the diseased sinus was popularized by Stammberger and Kennedy.[3,4] ESS is now accepted as the surgical management of choice of chronic sinusitis.

Imaging now provides the surgeon with a detailed “road map” for guiding the functional endoscopic sinus surgery procedure. CT was invented in 1972 by British engineer Godfrey Hounsfield of EMI Laboratories, England and by South Africa-born physicist Allan Cormack of Tufts University, Massachusetts. Hounsfield and Cormack were later awarded the Nobel Peace Prize for their contributions to medicine and science. Today, computed tomography (CT) is the modality of choice for the imaging evaluation of the morphology in this area. As with the development of ESS, there have been major advances made in Computed Tomography (CT) scan technology. Before CT scanning was available the extent of sinus disease and anatomy of nose and sinuses were assessed on plain X- ray films. Plain X-ray films are no longer used in this role, as they do not provide sufficient anatomical detail or accurate information on the extent of nasal and sinus pathology. The CT scan has allowed the evaluation of the anatomy of the sinuses in detail.[5]

One of the cause for chronic rhinosinusitis is the anatomical variations seen in ostiomeatal complex causing obstruction of natural ostium of sinuses. Dectection of these variations is important, and a vital step in evaluation of a patient with chronicrhinosinusitis, as this can prevent potiential complications of current endoscopic surgery on the sinuses. The investigative modalities available for the clinician are many like X ray, CT scan, DNE etc.

With the advent of of functional endoscopic sinus surgery (FESS) and coronal computed tomography (CT) imaging of paranasal sinuses, considerable attention has been directed toward paranasal region anatomy. Since conventional radiograph doesnot provide a detailed study of paranasal sinuses, has been largely been replaced by computerised tomographic (CT) imaging. Currently CT scanning is standard imaging in evaluation of paranasal sinuses as it gives the detailed study of anatomical views, and anatomical variations that are often seen in a patient with chronic rhinosinusitis.

Computerized tomography (CT) provides essential preoperative information for the assessment of patients undergoing functional endoscopic sinus surgery (FESS). One of the aim of CT of the sinuses is to delineate the extent of the disease, define any anatomical variants and relationship of the sinuses with the surrounding important structures. At present, CT scanning is the most commonly used imaging technique for assessing Sino nasal pathologies and defining the anatomic abnormality. The primary role of the coronal CT scan is to determine the extent and if possible the underlying cause. As a rule, surgeons individualize their surgical approach according to the extent and location of disease they see on CT scan. In our study, the anatomical variations of osteameatal unit has been evaluated.

METHODS

All adult patients (more than 20 years of age) who attended the Outpatient department at ENT department in Father Muller Medical College from September 2012 to September 2014, diagnosed to have chronic rhinosinusitis, willing to undergoing Computed Tomographic evaluation were included in this study

Sample of 50 were selected using purposive sampling technique. Computed tomography (plain study) images with Coronal sections of ostiomeatal complex were collected. After obtaining the preliminary lateral topogram of the skull, the area of scanning was defined to include the region from root of frontal sinus upto the hard palate. All CT scans were obtained with GE Brightspeed scanner (16 slice MDCT scanner). Coronal sections were performed with the patients in prone position, with extended neck and the plane perpendicular to the infraorbitomeatal line. The sections were taken with slice thickness of 2.5 mm. The scans thus generated were photographed at appropriate window widths and window level. They were analysed for anatomical variations using a soft parts window and a bone density window. In all cases, the existence of the following variants was investigated:

1. Nasal septum: septal deviation
2. Turbinates: middle concha bullosa, paradoxical (false) middle concha,
3. Uncinate process: deviation of the upper edge, pneumatisation;
4. Ethmoid air cells: frontoethmoidal cells, agger nasi cells, Haller's cells, great ethmoid bulla
5. Mucosal involvement of respective sinuses, maxillary, ethmoid, and frontal sinus
6. Other variants: hypoplasia of the maxillary sinus, maxillary septa, hypoplastic frontal sinus.
7. Associated anatomy of the paranasal regions such as asymmetry of ethmoidal roof was also investigated.

All adult patients presenting with history of nasal obstruction, nasal discharge, post nasal discharge and headache, clinically diagnosed to have Chronic rhinosinusitis (symptoms for a period of 12 weeks or more despite adequate medical treatment) and who are willing for computed tomography evaluation were included in this study.

Patients aged <20 years, patients with previous alteration of the paranasal sinus anatomy due to facial trauma, patients with tumours of the sinonasal mucosa, patients who underwent previous sinus surgery were not involved in the study.

Collected data was analysed by frequency, percentage and by Chi Square test. Excel software was used to analyze the statistical data.

Inclusion criteria for Study Group were adult patients presenting with history of nasal obstruction, nasal discharge, post nasal discharge and headache, clinically diagnosed to have chronic rhinosinusitis (symptoms for a period of 12 weeks or more despite adequate medical treatment), who are willing for Computed Tomographic Evaluation.

Exclusion criteria for Study Group were patients aged <20 years, patients with previous alteration of the paranasal sinus anatomy due to facial trauma, patients with tumours of the sinonasal mucosa, patients who underwent previous sinus surgery

RESULTS

During the period of 24 months of the study 50 patients who fulfilled inclusion criteria were studied, out of which 23 were female and 27 were male. Of the 50 cases studied, allergic symptoms were present in 7 patients, and polypoidal changes were seen in 6 patients. Mucosal abnormalities of sinuses were noted in 44 (88%) patients overall, maxillary sinus was involved in 32 (64%), ethmoidal sinus was involved in 22 (44%), frontal sinus was involved in 17 (34%). 45 (90%) patients presented some anatomical variant and, in many, more than one variant was present in the same subject.

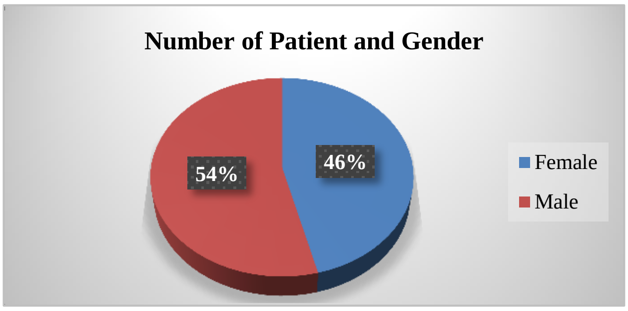

Figure 1: Number of patients and gender.

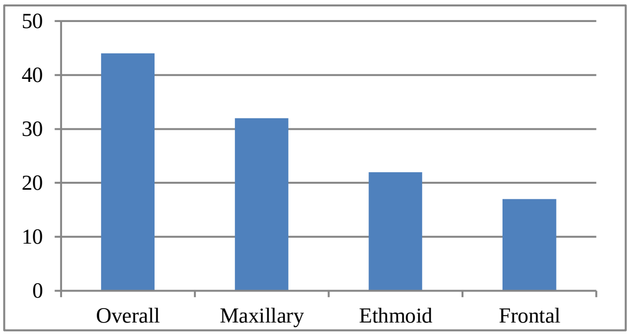

Figure 2: Coronal CT detection of mucosal thickening.

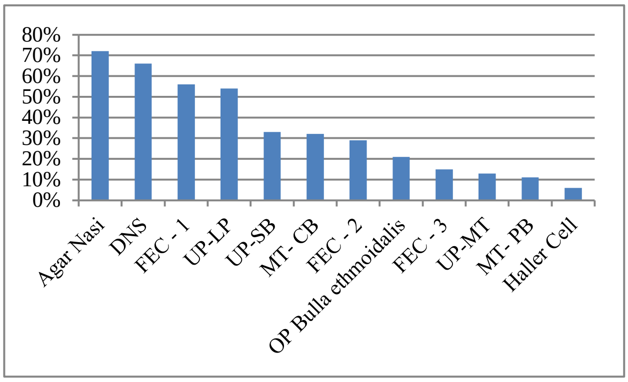

Figure 3: CT scan detection of anatomic variations.

Agger nasi was the most common variation seen in 72% cases followed by deviated nasal septum in 66% patients. Other variations found were lateral attachment of uncinate process in 54%, uncinate attachment to skull base in 33%, concha bullosa in 32%, overpneumatized bulla ethmoidalis in 21%, medial attachment of uncinate process to middle turbinate in 13%, paradoxical bent middle turbinate in 11%, haller's cell seen in 6%. 56% had type I frontoethmoidal cells, 29% had type II, and 15% had type III frontoethmoidal air cells. Combination of paradoxical bent and concha bullosa was seen in 1 case.

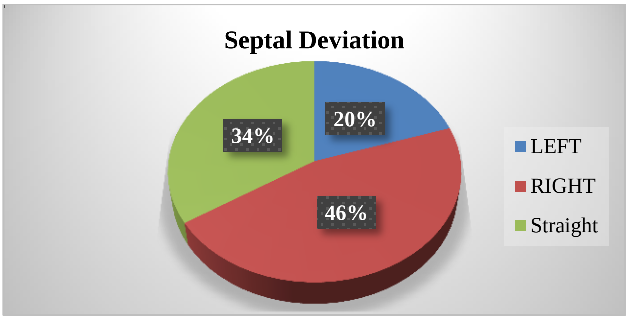

Figure 4: Coronal CT detection of septal deviation.

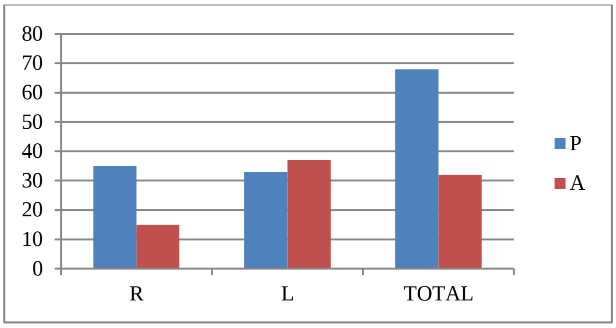

Figure 5: Coronal CT detection of Agger nasi.

Table 1: Frequency distribution of anatomical variations.

Anatomical variations	Percentage
Aggar Nasi	72%
Deviated nasal septum	66%
Frontoethmoidal cell Type – 1	56%
Superior attachment of unicinate process to lamina papyrecea	54%
Superior attachment of unicinate process to skull base	33%
MT- CB	32%
Frontoethmoidal cell Type – 2	29%
Overpneumatized Bulla ethmoidalis	21%
Frontoethmoidal cell Type – 3	15%
Superior attachment of unicinate process to middle turbinate	13%
Paradoxical bent of middle turbinate	11%
Haller's Cell	6%

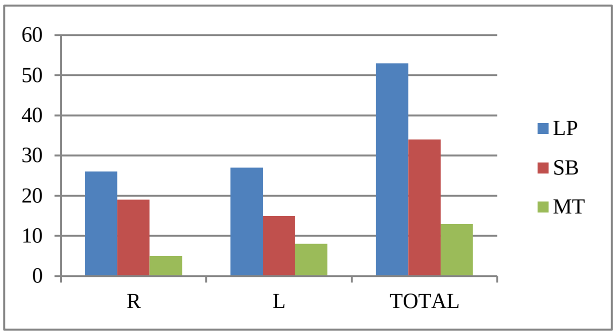

Figure 6: Coronal CT detection of superior attachment of uncinate process.

Considering both sides, frontoethmoidal cell type 1 was seen in 56 cases, out of which 20 frontal sinuses were involved, type 2 was seen in 29 cases, and frontal sinus was involved in 12, type 3 was seen in 15 cases and frontal sinus was involved in 6. Type 4 was not seen.

DISCUSSION

The term ostiomeatal unit was originally coined by Naumann, to identify its importance in pathogenesis of sinusitis.[5,6] The ostiomeatal unit is subject to a large variety of anatomical variations in this region and are important as they may have pathological consequence or may be the source of difficulty/ complication during surgery. Stumberger et al proposed that stenosis of the ostiomeatal complex, from either the anatomical configuration or hypertrophied mucosa, can cause obstruction and stagnation of secretions that may become infected or perpetuate infection.[6]

Concha bullosa (pneumatised middle turbinate) has been implicated as a possible aetiological factor in the causation of recurrent chronic sinusitis. It is due to its negative influence on PNS ventilation and mucociliary clearance in the middle meatus region. The presence of a concha bullosa has ranged between 4% and 80% in different studies; our data gave 32% which is less compared to 53.6% observed by Bolger and Zinreich et al (36%), and more compared to incidence reported by Dua (16%) and Peres et al (24.5%).[7,9] Such a wide range of incidence is due to the criteria of pneumatisation adopted.[8]

The middle turbinate may be paradoxically curved i.e. bent in the reverse direction. This may lead to impingement of the middle meatus and thus to sinusitis**.** In our study it was found in 11 patients (11%) - 8 unilateral, 3 bilateral. The incidence of 11% in our study is close to the 10% incidence described by Peres et al.[9]

A study done by Tuli et al showed superior attachment of uncinate process to lamina papyracea (67%) was the most common variety, the typical uncinate process was most common (70%) followed by medial deviation of the uncinate (24%).[10] And concluded that mere anatomical variations of uncinate process are not responsible for causing chronic sinusitis. In our study uncinate process was attached to lamina papyracea in 54% cases, and medial attachment was seen in 13%. Combination of some anatomic variations such as uncinate bulla and Haller's cell may increase pathogenic effect compared to the effect of single variant.

Haller's cells are ethmoid air cells that project beyond the limits of the ethmoid labyrinth into the maxillary sinus. They are considered as ethmoid cells that grow into the floor of orbit and may narrow the adjacent ostium. The incidence of Haller's cells in our study was 12 (6%) – 10 unilateral and 2 bilateral. Kenedy and Zinreich reported an almost similar incidence of 10%. It is less than that reported by Bolger (45.9%) and Asruddin (28%).[7,8,11]

Agger nasi cells lie just anterior to the anterosuperior attachment of the middle turbinate and frontal recess. These can invade the lacrimal bone or the ascending process of maxilla. These cells were present in 34 patients (72%) in our study. The incidence is less as compared to 98.5% by Bolger and more than that of 40% by Dua.[8] In anatomic dissections, Messerklinger encountered the Agger nasi cells in 10-15% of the specimens, Davis in 65% of specimens and Mosher in 40% of specimens.[12]

Various studies have reported the incidence of mucosal changes in paranasal sinuses. In our study maxillary sinus was involved in 32 (64%), anterior ethmoids in 22 (43%), and frontal sinus in 17(34%). Pansinusitis was seen in 14%. The extent of involvement reported by other authors was also in the same range. Zinreich published maxillary sinus involvement in 65%, frontal in 34%.[13] Bolger reported maxillary sinus involvement in 77.7%, ethmoids in 38.6%, frontal sinus in 36.6%.[8]

The clinical significance of anatomical variants of the nasal sinus region is controversial. Most CT anatomical studies of the sinus region have been made in patients suspected of a clinical syndrome suggesting inflammatory sinus pathology. Zinreich found that 62% of his patients presented at least one anatomic variant, against 11% in the normal control group.[14] These findings seem to suggest a positive correlation between anatomical variants and the appearance of inflammatory sinus pathology. However, Bolger et al, in a series of 202 patients studied by CT, observed 131 anatomical variants, but found the incidence in patients with sinus pathology was similar to that in persons studied for other reasons. Bolger et al and Stammberger & Wolf detected the presence of anatomical variants both in patients studied for sinus problems and in those studied for other reasons.[15,16] They concluded that the simple presence of variants does not mean a predisposition to sinus pathology, except when other associated factors are present. This opinion is not shared by Yousem, who claimed that the anatomical variants may be predisposing factors, depending on their size. In our study 44 (88%) patients had PNS mucosal abnormalities and 6 (12%) patients had no mucosal abnormalities. Anatomical variation were seen in 40 (80%) out of 44 patients with PNS mucosal abnormalities and 5 (77%) out of 6 patients without PNS mucosal abnormalities. From this observation our study also reveals that the presence of anatomical variants does not mean a predisposition to sinus pathology. However, it is important for surgeon to be aware of variations that may predispose patients to increased risk of intraoperative complications. The radiologist must pay close attention to anatomical variants in the preoperative evaluation and help avoid possible complications and improve success of management strategies.

CONCLUSION

Computed tomography of the paranasal sinus has improved the visualization of paranasal sinus anatomy and has allowed greater accuracy in evaluating paranasal sinus disease. It evaluates the ostiomeatal complex anatomy which is not possible with plain radiographs. Improvement in FESS and CT technology has concurrently increased interest in the paranasal region anatomy and its variations. Anatomical variations studied of PNS were found along with sinusitis. The radiologist must pay close attention to anatomical variants in the preoperative evaluation. It is important for surgeon to be aware of variations that may predispose patients to increased risk of intraoperative complications and help avoid possible complications and improve success of management strategies.

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